DOCUMENT RESUME

ED 463 152		SE 065 782
TITLE	Hubble Space Telescope Deep Field Lesson Package. Teacher's Guide, Grades 6-8. Amazing Space: Education On-Line from the Hubble Space Telescope.	
INSTITUTION	National Aeronautics and Space Administration, Washington, DC.	
REPORT NO	EG-1997(01)-002-GSFC	
PUB DATE	1997-00-00	
NOTE	74p.	
CONTRACT	NAS5-26555	
AVAILABLE FROM	Web site: http://www.stsci.edu/pubinfo/amazing-space.html.	
PUB TYPE	Guides - Classroom - Teacher (052)	
EDRS PRICE	MF01/PC03 Plus Postage.	
DESCRIPTORS	*Astronomy; Earth Science; *Inquiry; Junior High Schools; Middle Schools; *Science Activities; Science Education; Space Sciences	
IDENTIFIERS	*Hubble Space Telescope; National Science Education Standards	

ABSTRACT

This lesson guide accompanies the Hubble Deep Field set of 10 lithographs and introduces 4 astronomy lesson plans for middle school students. Lessons include: (1) "How Many Objects Are There?"; (2) "Classifying and Identifying"; (3) "Estimating Distances in Space"; and (4) "Review and Assessment." Appendices contain students sheets for other classroom activities and more useful information. (YDS)

Hubble Space Telescope Deep Field Lesson Package. Teacher's Guide, Grades 6-8. Amazing Space: Education On-Line from the Hubble Space Telescope.

National Aeronautics and Space Administration

Amazing Space:

Education On-Line from the Hubble Space Telescope

HUBBLE
Space Telescope
DEEP FIELD

Lesson Package

Grades 6-8
4 Classroom Activities
Lithographs
Teacher's Guide

Table of Contents

Introduction

Do you want to take your class on a field trip to the edge of the observable universe? If so, join Professor Wifpic and the cadets of the Hubble Academy as they count, classify and analyze objects from the Hubble Deep Field, almost 12 billion light-years away.

In this lesson, students will examine the Hubble Deep Field image and simulate the process astronomers use to count, classify and identify the objects in the image. These objects include spiral, elliptical and irregular galaxies, as well as a few individual stars.

Objectives

After completing this lesson, the student will be able to:

- Generate questions that can be answered using scientific inquiry
- Collect and interpret scientific data
- Describe the characteristics used to classify galaxies and explain the relationships between those characteristics
- Apply estimation skills to scientific data
- Begin to conceptualize the vastness of the universe

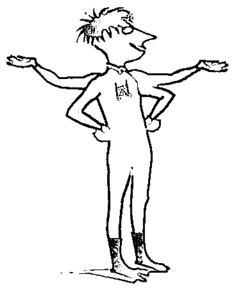
(For more information on content standards addressed by this lesson plan see page 3.)

How to Use the Teacher's Guide

The Teacher's Guide is designed to accompany the Hubble Deep Field set of ten lithographs. The guide provides background information, directions and student worksheets to allow the teaching of four activities related to the lithographs. These activities require students to gather and analyze data as they estimate and classify the objects in the Hubble Deep Field image.

The full field lithograph can be displayed to allow a view of the whole Hubble Deep Field image. For the estimation and classification activities, the guide includes handouts that students may use individually or in cooperative groups. The final activity provides an imbedded performance assessment that helps gauge student understanding of the concepts in the lesson.

To Find World Wide Web Resources



The Hubble Deep Field web-based lesson plan can be accessed at:
http://www.stsci.edu/pubinfo/amazing-space.html
Hubble Deep Field background information can be accessed at:
www.stsci.edu/EPA/background-text/hdf.txt
A tutorial on galaxies can be accessed at:
altair.syr.edu:2024/SETI/TUTORIAL/galaxies.html

To Obtain this Package

Contact NASA Headquarters Education Division or your local NASA Teachers Resource Center. A listing of the resource center nearest you can be accessed at: http://nssdc.gsfc.nasa.gov/planetary/ntrc.html

Warm-Up Activities

- Describe a possible method for estimating the number of objects in the Hubble Deep Field image.
- Think about and then write down several questions that you would like answered about the objects on the lithograph.
- Devise different ways to classify the objects in the Hubble Deep Field image.

General Background

Several hundred never-before-seen galaxies are visible in the "deepest-ever" view of the universe, called the Hubble Deep Field, made with NASA's Hubble Space Telescope. Besides the classical spiral- and elliptical-shaped galaxies, the image includes a bewildering variety of other galaxy shapes and colors that provide important clues to understanding the evolution of the universe. Some of the galaxies may have formed less than one billion years after the Big Bang.

Representing a narrow "keyhole" view all the way to the visible horizon of the universe, the Hubble Deep Field image covers a speck of sky 1/30th the diameter of the full moon. This is so narrow that just a few foreground stars in our Milky Way Galaxy are visible. These stars are vastly out numbered by the menagerie of far more distant galaxies—some nearly as faint as 30th magnitude, or nearly four billion times fainter than what the human eye can see. Though the field is a very small sample of sky area, it is representative of typical galaxy distribution in space. Statistically, the universe looks the same in all directions.

"Words from the Scientist"
Ray Lucas, Astronomer at the Space Telescope Science Institute

The study of the Hubble Deep Field is typical of the work astronomers do today in attempting to understand how galaxies formed and evolved over the history of the universe. When faced with objects we do not fully understand, we try to classify them based on their observable traits. We first have to see which traits are the most important to measure or count; and second, we have to decide which procedure to follow when using our classification system. Sometimes the most important characteristics or methods are also the easiest to see, but sometimes nature is more subtle. Sometimes we find that our ways of studying a problem are unwieldy or unsuitable. Sometimes even our fundamental assumptions about a problem are challenged, and we find that different questions need to be asked.

This is an exercise in which students can identify galaxies' observable traits for purposes of classification and then attempt to identify relationships and patterns among the traits. Once such patterns and relationships are established, the questions of why they exist and their significance can be addressed. Tests also can be designed to probe for more answers. Just as scientists find in their own everyday work, students will see that the answers are not always easy or clear and that some interpretation is always required. Perhaps even entirely new ways of looking at data may be required to reach plausible answers to questions.

This exercise helps students learn about the value of graphically representing data as a means of identifying trends, as well as the importance of sharing scientific results with peers. Although the lesson is designed for use in middle school science classes, it is hoped that these exercises will serve as a springboard that launches students into a lifetime of learning in any field of study. After all, even the oldest professional scientist is still a student of nature!

National Science Education Standards

National Academy Press, 1996

CONTENT STANDARD A

As a result of activities in grades 5-8, all students should develop:

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

- IDENTIFY QUESTIONS THAT CAN BE ANSWERED THROUGH SCIENTIFIC INVESTIGATIONS:
  Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. **Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation** (p. 145).

- RECOGNIZE AND ANALYZE ALTERNATIVE EXPLANATIONS AND PREDICTIONS:
  Students should develop the ability to listen to and respect the explanations proposed by other students. **They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations** (p. 148).

- COMMUNICATE SCIENTIFIC PROCEDURES AND EXPLANATIONS:
  With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations (p. 148).

- USE MATHEMATICS IN ALL ASPECTS OF SCIENTIFIC INQUIRY:
  Mathematics is essential to asking and answering questions about the natural world. **Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations** (p. 148).

UNDERSTANDING ABOUT SCIENTIFIC INQUIRY

- **Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances** (p. 148).

Content Standard G

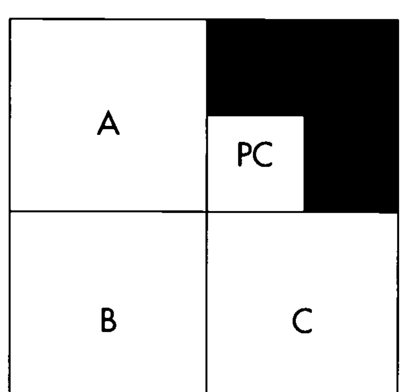
As a result of activities in grades 5-8, all students should develop understanding of:

NATURE OF SCIENCE

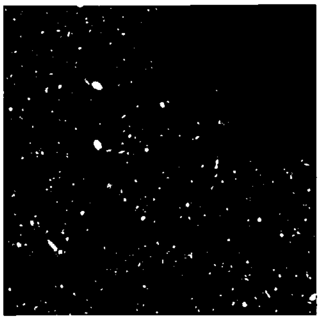
- **It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation included reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists** (p. 171).

Shape of the Hubble Deep Field Image

The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Activity One: How Many Objects Are There?



One of the questions astronomers asked about the Hubble Deep Field image was, "How many objects are there?" Scientists often have to come up with rough estimates, which they will later verify with further investigations.

Introduction

In this activity, students will practice estimation skills as they begin to explore the Hubble Deep Field image. They will first give a rough "ball park" estimate of the number of objects in the image. They will then follow several steps, using representative sampling techniques to improve on their original estimates. Finally, they will calculate the number of similar objects in the universe, based on their own estimate. Prior to beginning the lesson, the teacher and students must agree on a protocol for counting the objects. They must agree on how to count objects that appear in more than one section and address other issues that could lead to inconsistent counting.

Representative sampling

Representative sampling is a technique used for counting large quantities. First, researchers develop an estimate based on a small section. They then multiply the estimate by the number of sections in the entire area being counted.

The Hubble Deep Field is an excellent image to use for representative sampling. The Hubble Deep Field is divided into three areas, or cameras, called A, B, and C. Each camera is further divided into 12 sections labeled by rows 1-4 and columns a-c.

Instructions

1. Ask students to brainstorm and write down several situations in which a scientist might best use a rough estimate rather than an exact count.

2. Ask students to estimate the number of objects in the Hubble Deep Field and record their estimate on the worksheet.

3. Assign each group one camera (A, B, or C) from the Hubble Deep Field to use for representative sampling. Reproducible copies of the three cameras are provided (pages 6, 7, 8). Astronomers prefer to use negative or reversed images – dark objects on a light field – because they are easier to distinguish between objects. Each student can count a different section of the camera (12 sections in each). Students then can use this information to calculate a group as well as a class average.

4. The teacher should decide whether to use individual, group or class estimates to do the following calculations:

____________ x 12 = X

(Student's count from one section of one camera)

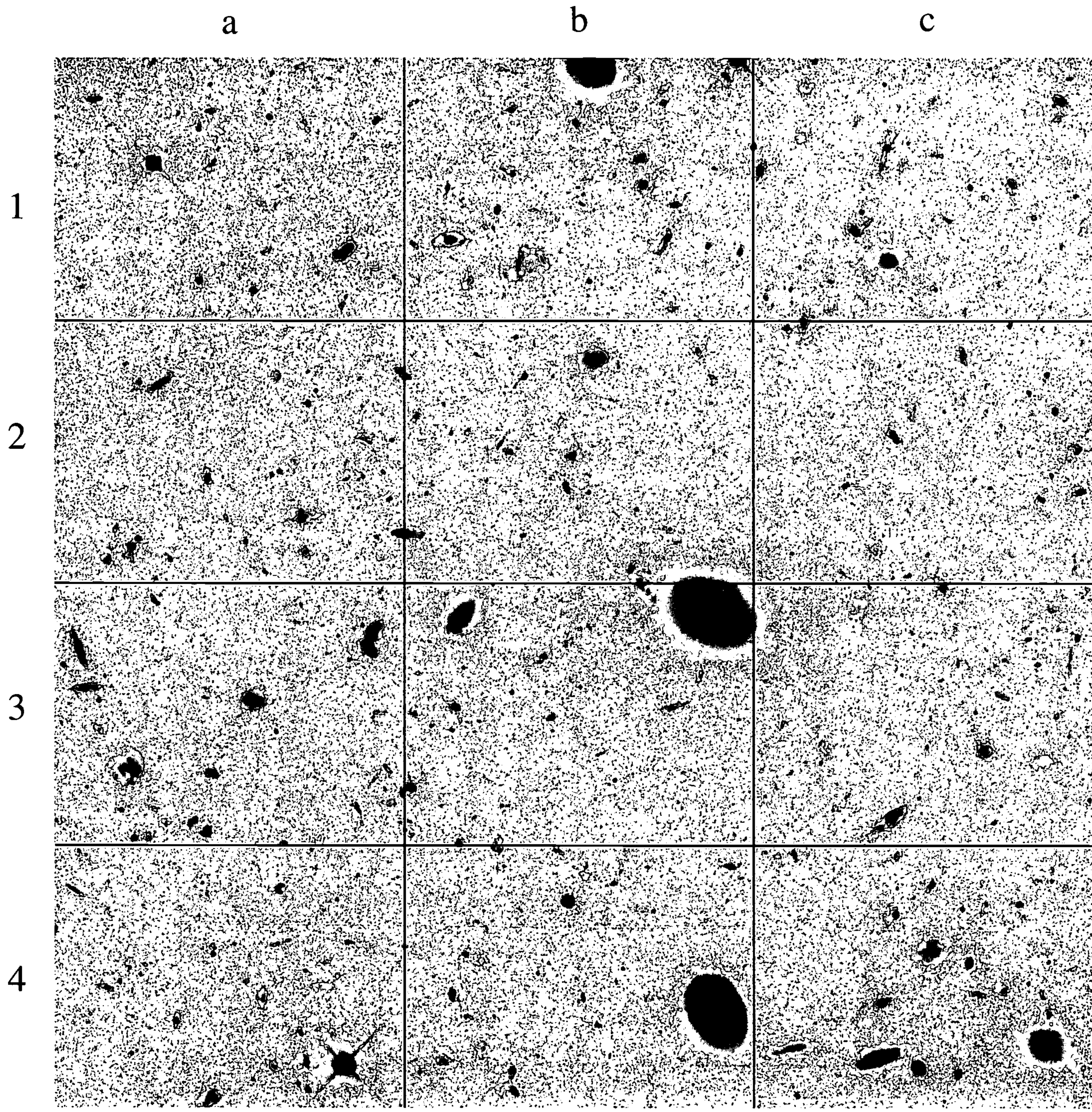
X x 3 = Y

Y x 3 x 10^7 = Z

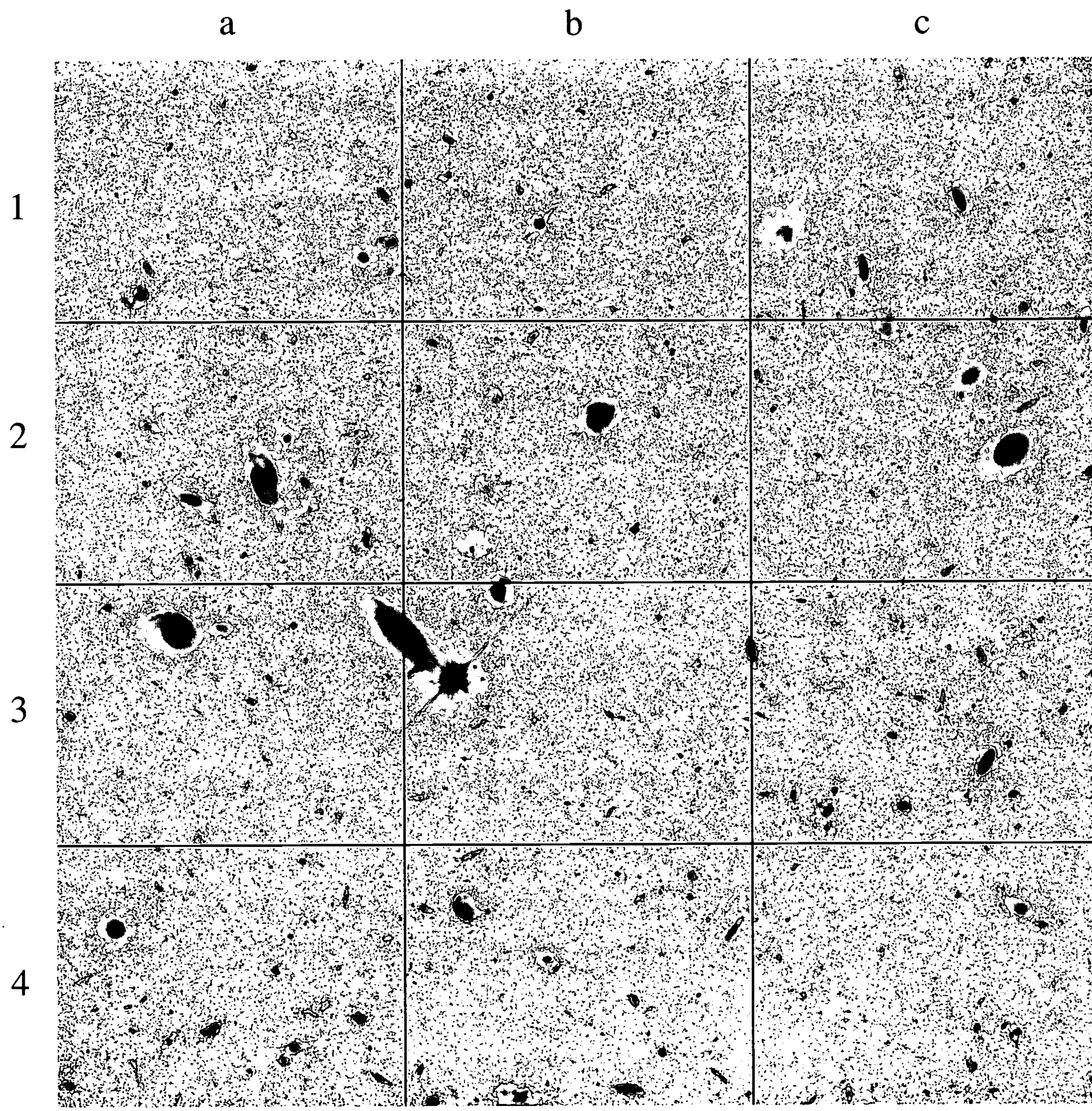
X = objects in one camera section Y = objects in Hubble Deep Field Z = objects in the universe

5. The teacher should share with students the astronomers' estimates for the number of objects in the Hubble Deep Field (~3,000) and in the universe (50-100 billion). Students should compare their estimates with those of astronomers' and attempt to explain the wide range of numbers that are possible.

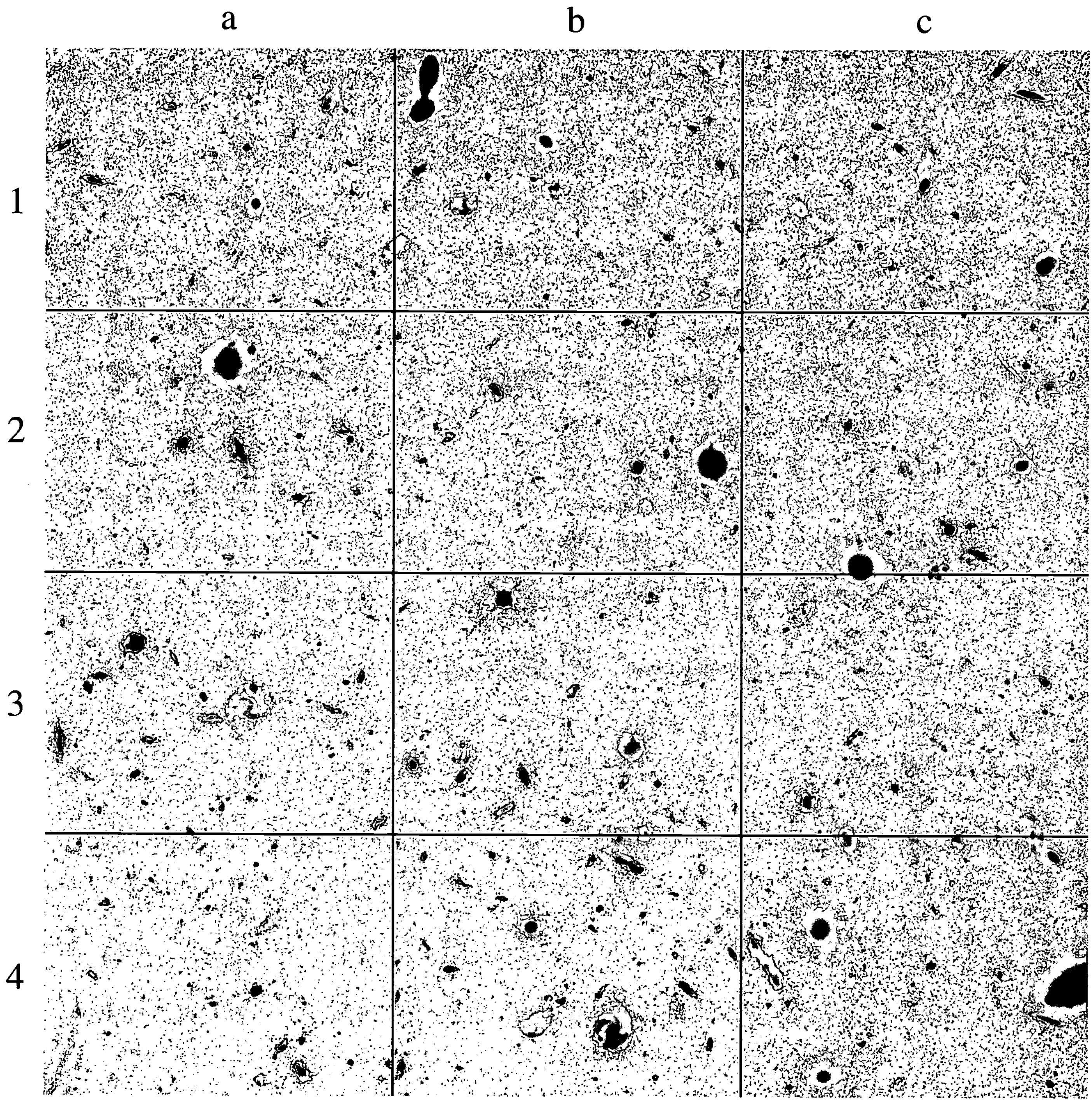
Camera A



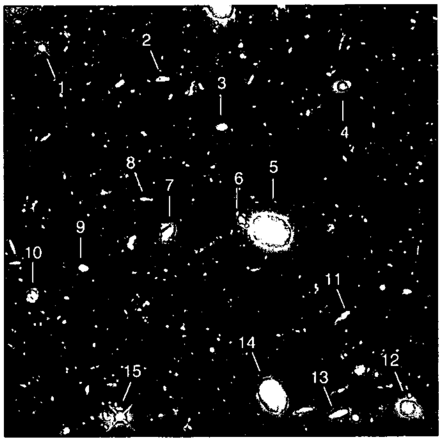
Camera B

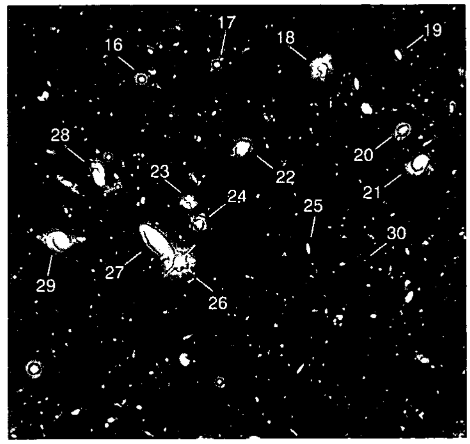


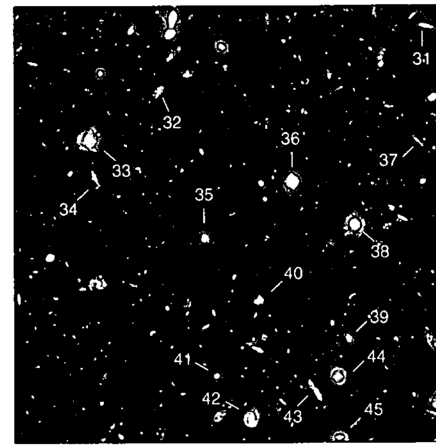
Camera C



Activity Two: Classifying and Identifying







Introduction

In this lesson, students will classify selected objects from the Hubble Deep Field based on their color and shape. It is recommended that you assign several students to each of the three cameras of the Hubble Deep Field image. Students will classify the 15 numbered objects within their assigned camera, but can do more if they have time. This activity requires the color lithographs.

Students will then compare their classification with a chart made by astronomers. The chart represents the opinions of almost a dozen scientists from the Space Telescope Science Institute who volunteered to complete the same task.

Instructions

1. Assign each group of students a camera (A, B, or C) from the Hubble Deep Field.

2. Instruct students to classify the objects based on color and shape using the chart from the worksheet. Summary information is included in "Classifying and Identifying Objects," on page 11. If time permits, allow students to trade cameras so they can examine all of the objects. Otherwise, have the groups share their data so all students have information about all 45 objects.

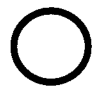
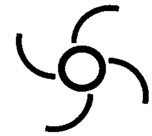
3. Present an overhead of the astronomers' chart (page 10) to the class and have students answer questions 1-3 in Part Two on the worksheet.

4. Have students develop ideas about why some sections of the chart are particularly full or completely empty. Students should use the astronomers' chart to answer questions 1-3 in Part Three of the worksheet.

5. Share with students the information from the workbook on stars and different galaxy shapes. Have students answer questions 1 and 2 in Part Four of the worksheet.

6. Discuss with students the importance of sharing scientific data. Brainstorm ways to speed up the process.

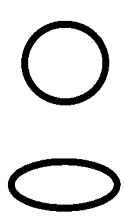
Astronomers' Chart

					Irregular
Blue	35	-	-	10,28,29	2,6,18,23, 32,43
White	1,17,26	36,4	5,8,19, 25,34	3,14,21	9,33,38,40
Yellow	15	12,41	7,13	22, 24, 27, 31	-
Red	-	16,44,45	20,30,37	39,42	11

Classifying and Identifying Objects

Stars: Stars are massive, gaseous bodies that undergo nuclear reactions and emit light. Stars do not really have spikes, even though they appear that way in the Hubble Deep Field. These spikes are caused by scattered light within the telescope's optical assembly.

Spiral Galaxies: Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, a spiral galaxy resembles a fried egg. Some of the long, narrow objects in the Hubble Deep Field may be side views of spiral galaxies. The spirals in the Hubble Deep Field are mostly blue and white because of recent star formation, particularly in the spiral arms.



Elliptical Galaxies: Elliptical galaxies come in a variety of shapes ranging from round to flattened. Elliptical galaxies have a smooth, featureless appearance and appear basically the same from any angle. Most of the elliptical galaxies in the Hubble Deep Field are yellow and red because they do not contain young stars.

Irregular Galaxies: Irregular galaxies have stars, dust, and gas scattered in random patches. The irregular galaxies in the Hubble Deep Field tend to have a blue or white color because recent star formation makes galaxies appear bluer.

Activity Three: Estimating Distances in Space

Introduction

In this activity, the problems and difficulties of determining the distances between Earth and objects in space will be addressed. Students will attempt to arrange five objects in the Hubble Deep Field according to their distances from Earth. After entering their answers based on visual observations alone, the students will compare their answers with those of astronomers and try to explain why they differ.

Instructions

1. Assign each group a camera (A, B, or C) from the Hubble Deep Field.

2. Ask students to use their worksheet to identify the five objects they will be examining for this activity. If the lithographs are laminated, students can circle the objects with an overhead pen or label them with post-it notes.

Camera A: [3, 4, 7, 13, 14]

Camera B: [19, 21, 22, 27, 29]

Camera C: [33, 36, 41, 42, 44]

3. Students should then answer questions 1 and 2 in Part One of their worksheets.

4. After students have answered questions 1 and 2 in Part One, reveal the astronomers' specific order for each camera. Have students compare their answers with those of the astronomers.

5. Have students answer the question in Part Two of their worksheets.

6. Discuss the fact that the size of an object does not always give an accurate impression of its distance from Earth. Astronomers must study the light from the object to determine its distance.

7. Provide students with the astronomers' explanation. Have students answer questions 1 - 3 in Part Three on the worksheet.

Answers

Order suggested by astronomers, based on their study of the objects' light.

(closest...farthest)

Camera A: [4, 14, 13, 7, 3]

Camera B: [29, 21, 19, 27, 22]

Camera C: [36, 33, 41, 44, 42]

(Answer key transparency master provided on page 13.)

Estimating Distances in Space

Astronomers cannot use size alone to estimate an object's distance from Earth. Small objects can be close and still appear small when compared with a much larger, more distant object. To estimate the distance of an object, astronomers also must study the light it emits.

Order suggested by astronomers based on their study of the objects' light (from closest to farthest)

Camera A: [4, 14, 13, 7, 3]

Camera B: [29, 21, 19, 27, 22]

Camera C: [36, 33, 41, 44, 42]

Activity Four: Review and Assessment

Introduction

This lesson is intended to be a review of the concepts presented in the other activities as well as an assessment of students' understanding of the lesson. Students will use the review information from the activities as they answer questions. Students will then view an image of an object that even astronomers had difficulties classifying. Students will make their own interpretations of the object, based on knowledge acquired from the lesson. Lastly, astronomers' interpretations will be presented for students to compare with their own answers.

Instructions

* Before beginning this activity, review what students have learned by completing the other activities. Review materials summarized in "About Galaxies," page 15.

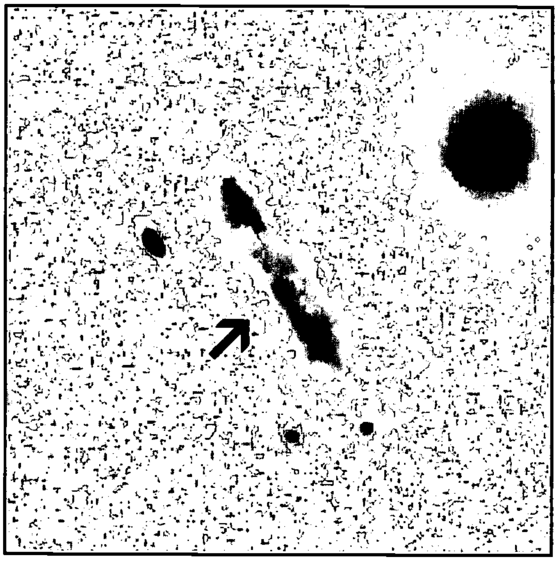
1. Using the knowledge gained in the previous activities, have students answer questions 1-6 in Part One of their worksheets.

2. Using the Hubble Deep Field image found on the following page, have students attempt to identify the object that astronomers consider to be an "oddball."

3. Using their knowledge of galaxies, students should then answer questions 1-3 in Part Two of their worksheets.

4. Present each group with astronomers' description/explanations of the object. Students should compare their answers and complete questions 1 and 2 in Part Three of their worksheets.

5. Discuss with students the possibility of more than one acceptable interpretation. Scientists don't always agree!



NOTE: The "oddball" object is located in camera C, section 4c. It is the elongated object in the center left area of this section.

About Galaxies

Galaxies: Galaxies are massive systems made of billions of stars, dust and gas clouds held together by gravity.

Stars: Stars are massive, gaseous bodies that undergo nuclear reactions and emit light. Stars do not really have spikes, even though they appear that way in the Hubble Deep Field. These spikes are caused by scattered light within the telescope's optical assembly.

Galaxy Shape: Astronomers use shape to classify galaxies. There are three commonly recognized shapes: spiral, elliptical and irregular. Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like a fried egg. Elliptical galaxies have a smooth and featureless appearance, and are either round or oval in shape. They appear basically the same when viewed from any angle. Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches. The most difficult part about identifying galaxies by their shape is being able to recognize them when their orientation is unknown.

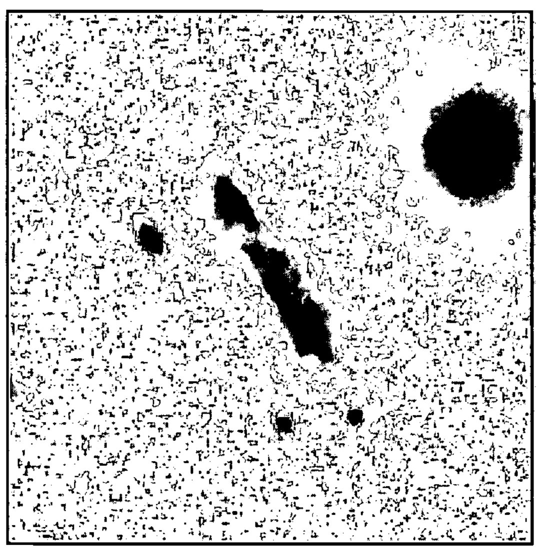
Galaxy Color: Galaxies come in a variety of colors. As a galaxy ages, its color changes. Galaxies with young stars appear blue, while galaxies with old stars appear red. Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red. The presence of dust in a galaxy can make it appear more red than it actually is. By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Galaxy Size/Distance: Determining an object's distance from Earth is a difficult task for astronomers. The size of a galaxy is not useful because objects that are large can appear close next to objects that appear smaller but are extremely large and far away. Astronomers study the light from galaxies to determine their distance, measured in light-years. A light-year is equal to the distance light can travel in a year, approximately 6 trillion miles (a six with 12 zeros).

Galaxy Population: Astronomers have long tried to estimate the number of galaxies in the universe. They use a method called "representative sampling." To obtain their estimate, they first divide the sky into sections of equal size. Astronomers then count the number of galaxies in one section. The count from that one section is then multiplied by the total number of sections in the sky. Astronomers have estimated the number of galaxies in the universe to be between 50 and 100 billion.

What is This?

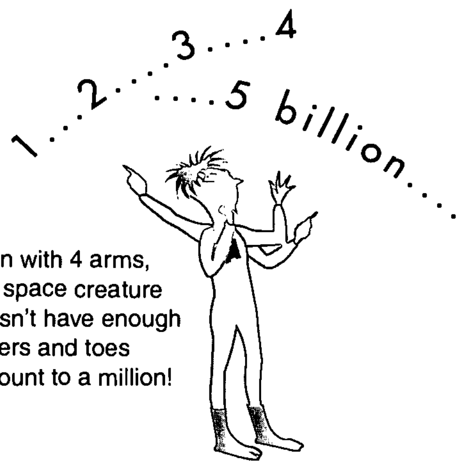
Some of the academy's astronomers believe that the so-called "oddball" object is an irregular galaxy. Its purplish color may be caused by a combination of star formation and dust in the galaxy. Dust absorbs and scatters light and makes a galaxy appear more red. Other astronomers believe it is a system of two or more galaxies merging. As you can see, even astronomers do not always agree.



NOTE: The "oddball" object is located in camera C, section 4c. It is the elongated object in the center left area of this section.

Appendix A

Name: ______________________________ Date ______________



Even with 4 arms, this space creature doesn't have enough fingers and toes to count to a million!

Activity One: How Many Objects Are There?

So, how many objects did you find in the Hubble Deep Field image, anyway? This is the question most often asked by students and Hubble astronomers.

As you know, scientists are often asked to give rough estimates during their investigations. Brainstorm for a moment, and then write down several situations in which a scientist might best use a rough estimate rather than an exact count.

1. ____

____

2. ____

____

3. ____

____

Now we would like you to take a good look at the Hubble Deep Field image. Give a rough estimate of the number of objects in it.

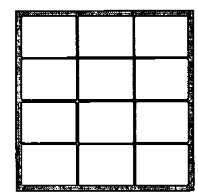
Your rough estimate:

I think there are ____________________ objects in the Hubble Deep Field image.

Sometimes, however, scientists need more accurate estimates. So, they must then gather more data and use it to revise their rough estimates. Your next mission is to use a technique called "representative sampling" to improve your original estimate.

Representative sampling: Follow these steps to complete a more precise estimate.

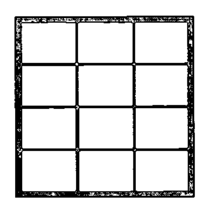
1. Please select one of the three cameras (A, B, or C) of the Hubble Deep Field image. Then count all the objects in just one of the 12 smaller sections.



There are ________________________ objects in one of the 12 sections of camera __________________ in the Hubble Deep Field image.

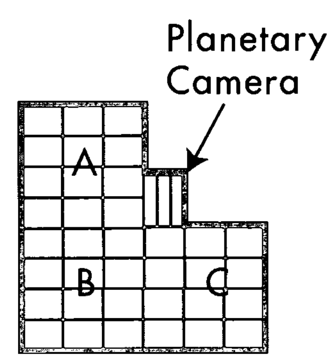
Note:
Though the Hubble Deep Field is a very small sample of the heavens, it is considered representative of typical galaxy distribution in space.

2. Using your count from question number (1) above and your math skills, please calculate the approximate number of objects in the camera you selected.



There are approximately ____________________ objects in camera ________________ in the Hubble Deep Field image.

3. Now, consider all three cameras (A, B, and C). How many objects appear in the Hubble Deep Field image? (For purposes of this activity, the Planetary Camera has not been factored into these calculations.)



There are approximately____________________objects in the Hubble Deep Field image.

Factoid: The Hubble Deep Field image covers an area in the sky as small as President Roosevelt's eye on a dime held at arms length.

4. Now that you have calculated an approximate number of objects in the Hubble Deep Field image, how many objects do you think exist in the universe?

I think there are approximately ____________________________ objects in the universe.

5. Using the same information you now have, astronomers recently recalculated the number of similar objects in the universe. Using a multiplier ($3x10^7$) provided by the Hubble Deep Field team of astronomers, you can calculate your own estimate.

______	×	3×10^7	=	______	objects in the universe.
Your Hubble Deep Field number of objects		Multiplier			

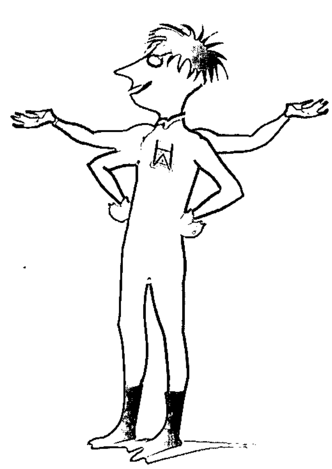
According to the astronomers, there are between 50 billion and 100 billion similar objects in the known universe.

Compare your estimate with that of the astronomers. Please answer these questions in complete sentences.

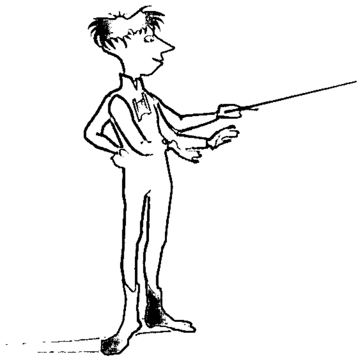
6. Is your estimate within the astronomers' range? How close did you get?

7. Given your experience with calculating a representative sample, give your explanations for the wide range in the astronomers' estimate.

Good work!



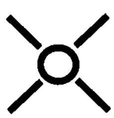
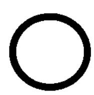
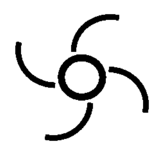
Name: ______________________________ Date ____________________



Activity Two: Classifying and Identifying

Part One: Using one of the three cameras (A, B, or C) of the Hubble Deep Field image, classify the objects according to their shape and color. For example, if object number 4 is blue and round, place a number 4 in the box where the blue row and round column intersect.

Classification chart for Hubble Deep Field section:

					Irregular
Blue					
White					
Yellow					
Red					

Part Two: Using the astronomers' and your chart, answer the following questions.

1. List three objects that you and the astronomers classified the same.

____________________ ____________________ ____________________

2. List three objects that you and the astronomers classified differently.

____________________ ____________________ ____________________

3. If applicable, give two reasons why you and the astronomers might have disagreed.

A. ____

____

B. ____

____

Part Three: Use the astronomers' chart to answer the following questions.

1. How many groups have at least five or more objects in them?

____

____

2. Choose any one group and describe the characteristics of its members.

____

____

3. What do you think the objects in the group you selected are? Give a reason to support your hypothesis.

____

____

Part Four: Compare your hypothesis with the explanation from the astronomers and answer the following questions.

1. List one similarity between the astronomers' explanation and your hypothesis regarding the group of objects you selected.

____

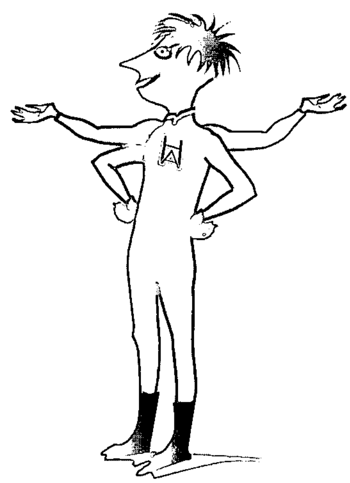
____

2. List one difference between the astronomers' explanation and your hypothesis regarding the group of objects you selected.

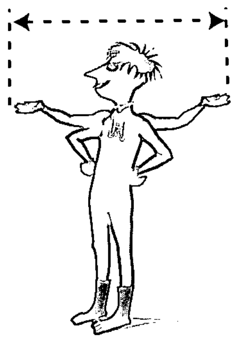
____

____

Good work!



Name: ______________________________ Date __________________



Activity Three: Estimating Distances in Space

If you were to travel to some of the objects in the Hubble Deep Field, you would need to determine their distances. This has been a difficult task for astronomers. At this time, they only have distance information for a few of the objects.

Your job is to determine the relative distances to the five objects in your selected camera. Your input will be used to help plan a travel route and schedule.

Part One: Depending on which camera you selected (A, B, or C), arrange the five selected objects according to their relative distances from Earth. Here are the five selected objects per camera:

Camera A: [3, 4, 7, 13, 14]
Camera B: [19, 21, 22, 27, 29]
Camera C: [33, 36, 41, 42, 44]

1. Start your list with the object you think is the closest to Earth and end with the object you think is the farthest.

________ ________ ________ ________ ________ ________

(closest) (farthest)

2. Explain why you arranged the objects as you did. Be sure to mention any particular trait on which you based your decision.

____

____

Part Two: Explain how is it possible that smaller objects could be closer than larger, more distant objects.

____

____

Part Three: Read the astronomers' explanation about estimating distances in space.

1. How is your explanation (to the question in Part Two) similar to that of the astronomers?

____

____

____

2. How is your explanation (to the question in Part Two) different from that of the astronomers?

____

____

____

3. If you were to visit the five objects in your specific camera, in what order would you visit them? Please, explain your answer.

__________ __________ __________ __________ __________

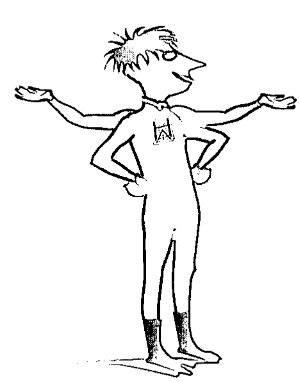
(first) (last)

Explain: ____

____

____

Good work!



Name: ______________________________ Date ____________________

Activity Four:
Review and Assessment

Part One: Using the knowledge gained in the previous activities, answer the following questions.

1. What is the difference between a galaxy and a star?

2. What does the color of a galaxy indicate?

3. What does the shape of a galaxy indicate?

4. Why isn't size alone useful in determining a galaxy's distance from Earth?

5. Explain how a spiral galaxy can look like this  or like this .

6. Describe the process used by astronomers to estimate the number of galaxies in the universe. Be sure to explain what mathematical calculations must be performed.

____

____

Part Two: Look at the picture of the object in the Hubble Deep Field considered by astronomers to be an "oddball." Using your knowledge gained in the previous activities, make some predictions about this object.

1. What does the color of this object tell you?. The "oddball" object is located in Camera C, Section 4c (the "oddball" is the elongated object in the center left area of this section.)

____

____

2. What does the shape of this object tell you?

____

____

3. What do you think this object is? Please give justification for your answer.

____

____

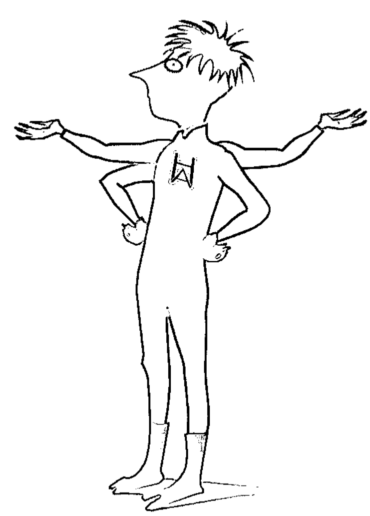
____

Part Three: Compare your predictions about the "oddball" object to the explanation given by astronomers. Answer the following questions.

1. What similarities exist between your predictions about the "oddball" object and the astronomers' explanations?

2. What differences exist between your predictions about the "oddball" object and the astronomers' explanations?

Good work!



Name: ______________________ Date: ______________________

What Does a Million Look Like?

When we study the age of the Earth, the solar system, and the universe, we are dealing with huge numbers. The size of these numbers is very hard for people to comprehend. To gain a better idea of the magnitude of these numbers, we are going to count dots – millions, billions, and trillions of them.

Please read all questions carefully and show any work necessary to calculate your answers. All questions refer to the number of dots on the worksheet.

1. How many dots are there on the worksheet? ______________

2. How many pages would it take to make 1 million (1,000,000) dots? ______________

3. How many pages would it take to make 1 billion (1,000,000,000) dots? ______________
   1 trillion (1,000,000,000,000) dots? ______________

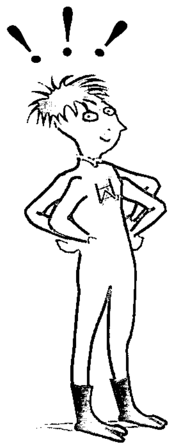
4. If 250 stacked pages equals 2.5 centimeters, how many centimeters of paper would it take to make 1 million dots? ______________
   To make 1 billion dots? ______________
   To make 1 trillion dots? ______________

5. There are approximately 5 billion people in the world. If each dot represented one person, how many pages would be necessary to show the Earth's population?
   ____

6. How many centimeters of dotted paper would represent the population of the world? ______________
   How many meters? ______________
   Compare the height of this stack of papers to a tall office building.
   If each story equals 3 meters, how tall would the building be?
   Answers: _______centimeters,_______meters,_________ stories.

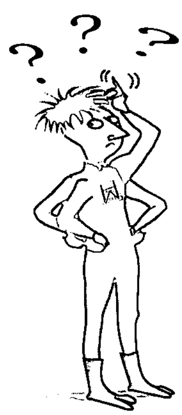
Even with 4 arms, this space creature doesn't have enough fingers and toes to count to a million!

What Does A Million Look Like – Worksheet



Please show all your work.

Name: ______________________________ Date: ________________



How Many's a Million? Billion? Trillion?

By Kirk Fitch, Takoma Park Middle School, Silver Spring, MD

Counting large numbers: If you were to count numbers at a rate of 1 per second, how long would it take you to count up to a million? How about a billion? And if you got really ambitious and tried counting to a trillion? Do you think you could do it?

Take a few minutes to think about this challenge. Do you foresee any problems or questions that might come up as you attempt this exercise? Write down two or three of the problems you might run into in the space below.

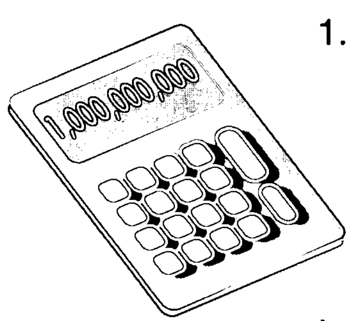
____

____

____

____

Calculating your answers: In the space below, calculate your answers to the counting questions. Assume that you are taking no breaks for things like eating or sleeping.



1. How long would it take to count to 1,000,000?

1,000,000 / 60 = ____________ minutes

________ / 60 = ____________ hours

________ / 24 = ____________ days ________hours

It would take me ______________________________ to count to 1 million.

How Many's a Million? Billion? Trillion?

2. How long would it take to count to 1,000,000,000?

_______________ / __________ = ______________ minutes
_______________ / __________ = ______________ hours
_______________ / __________ = ______________ days
_______________ / __________ = __________years __________ days

It would take me ______________________________ to count to 1 billion.

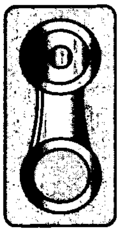
3. How long would it take to count to 1,000,000,000,000?

_______________ / __________ = ______________ minutes
_______________ / __________ = ______________ hours
_______________ / __________ = ______________ days
_______________ / __________ = __________years __________ days

It would take me ______________________________ to count to 1trillion.

Bonus question: If there were 1 quadrillion stars in a cluster of galaxies, how long would it take you to count them? Please show all your work below and clearly label your answer.

Name: ______________________________ Date ____________



999,999 Cans of Soda on the Wall?

By Kirk Fitch, Takoma Park Middle School, Silver Spring, MD

Did you ever stop to think how long it would take to drink 999,999 (or even 1 million!) cans of your favorite soda? How about you and a friend? You and your entire class? The whole school? In this activity you will be asked to think about and make some predictions about this very thing.

1. If you drank five sodas a day, how long would it take you to drink 1 million? _______ days.

2. If you and a friend both drank five cans of soda a day, how long would it take? _______ days.

3. How long would it take the entire class? 1,000,000 ÷ (5 cans X number of students = _______) = _______ days.

4. How long would it take the entire school? Write your own equation to answer this question.

5. If everyone in your county drank one soda a day how long would it take to go through 1 million?

6. If everyone in your class saved their pull tabs and brought them to school, how long do you think it would take to save 1 million of them? _______ days. In your journal, explain the method you used to arrive at your estimate.

Glossary

Big Dipper: A constellation located in the northern sky.

Hubble Deep Field: An area of the sky, located near the Big Dipper, photographed by the Hubble Space Telescope.

Galaxy: A massive system of stars held together by their mutual gravity.

Hubble Space Telescope: An automated reflecting telescope which orbits the Earth, built by the National Aeronautics and Space Administration. It contains instruments capable of receiving many types of light.

Milky Way Galaxy: The specific galaxy to which the Sun belongs, named because most of its visible stars appear overhead on a clear dark night as a milky band of light extending across the sky.

Representative Sampling: A technique for counting large quantities, uses an estimate based on a small section which is multiplied by the number of sections in the entire area being counted.

Star: A massive gaseous body that is held together by gravity and emits light.

Universe: All existing things, including Earth and its creatures and all the heavenly bodies.

Wide Field Planetary Camera: An instrument on the Hubble Space Telescope that takes images in a variety of colors. Referred to as WFPC, pronounced "wif pic."

How to contact STScI

To electronically access Hubble Space Telescope press releases and associated captioned images and background information, you can use the Internet via World Wide Web, ftp or Gopher.

Internet

www: http://www.stsci.edu

Gopher

www.stsci.edu to STScI Gopher Information Service

World Wide Web (Mosaic, etc.)

- Start Mosaic, Netscape, Lynx or other Web browser
- Open URL: "http://www.stsci.edu"
- To copy images or other documents to the local system rather
  than viewing directly, set the option in Moasic: "Load to Local Disk".
- To get to the Space Telescope Science Institute Office of Public Outreach (OPO) use the URL: " http://www.stsci.edu/pubinfo/amazing-space.html"

Credits

Educators:

Gina Cash
Earth and Life Science Teacher
Hammond Middle School
8110 Aladdin Drive
Laurel, MD 20723

Kirk Fitch
Elementary and Earth Science Teacher
Takoma Park Middle School
7611 Piney Branch Road
Silver Spring, MD 20910

Scientist:

Ray Lucas
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218

and the staff of the Office of Public Outreach

Using Direct-dial Modem

If you do not have internet access, you can still electronically retrieve HST images, as well as images from other sites, via NASA's SpaceLink. SpaceLink's modem line is 205-895-0028. The TCP/IP address is 192.149.89.61.

When you connect, a welcome screen will appear with instructions for logging onto the system.

- At the login prompt, type "guest"
- You can navigate through the SpaceLink system by using the menu options. Additional information on how to use the system can be accessed from the main menu.

The SpaceLink system also fully supports the following Internet services:

• World Wide Web	http://spacelink.msfc.nasa.gov
• Gopher	spacelink.msfc.nasa.gov
• Anonymous FTP	spacelink.msfc.nasa.gov
• Telnet	spacelink.msfc.nasa.gov

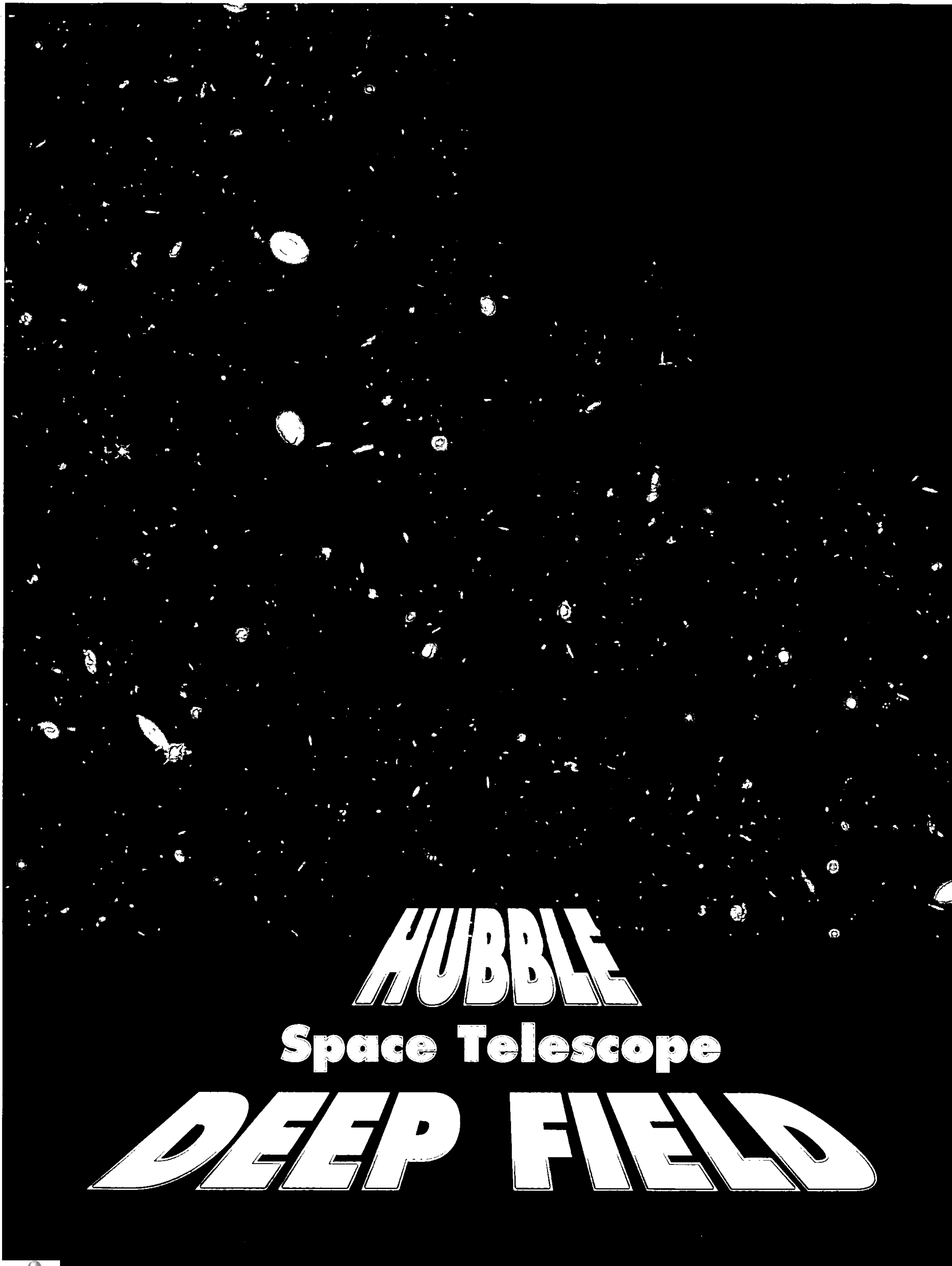
Electronic Distribution of STScI Press Release Text
To receive Space Telescope Science Institute press release text via e-mail automatically, subscribe to the STScI Public Information list server:

- Send e-mail to "listserv@stsci.edu"
- Leave the Subject field blank
- In the body of the message, write "subscribe pio <Name>".

Replace "<Name>" with your real name (not a user/account name) without the brackets and quotes. For example, someone named Jane Doe would use: subscribe pio Jane Doe

You will receive acknowledgment of your subscription via e-mail and receive e-mail with new press releases.

EG - 1997 (01) - 002 - GSFC


HUBBLE
Space Telescope
DEEP FIELD

Galaxies
- Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape
- Astronomers use shape to classify galaxies.
- There are three commonly recognized shapes: spiral, elliptical, and irregular.

Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.

Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.

Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
- The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

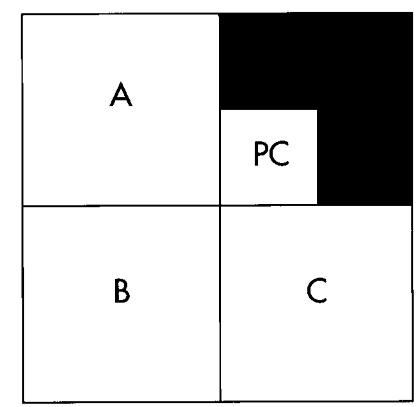
Color
- Galaxies come in a variety of colors.
- As a galaxy ages, its color changes.
- Galaxies with young stars would appear blue; galaxies with old stars would appear red.
- Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
- The presence of dust in a galaxy can make it appear more red than it actually is.
- By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance
- Determining the distance from Earth for objects in space is a difficult task for astronomers.
- The size of a galaxy is not useful because objects that are nearer to Earth can appear small next to other objects that are extremely large and far away.
- Astronomers study the light from galaxies to determine their distance, which is measured in light-years.
- A light-year is equal to the distance light can travel in a year, approximately 6 trillion miles.

Hubble Deep Field–Full Image
The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

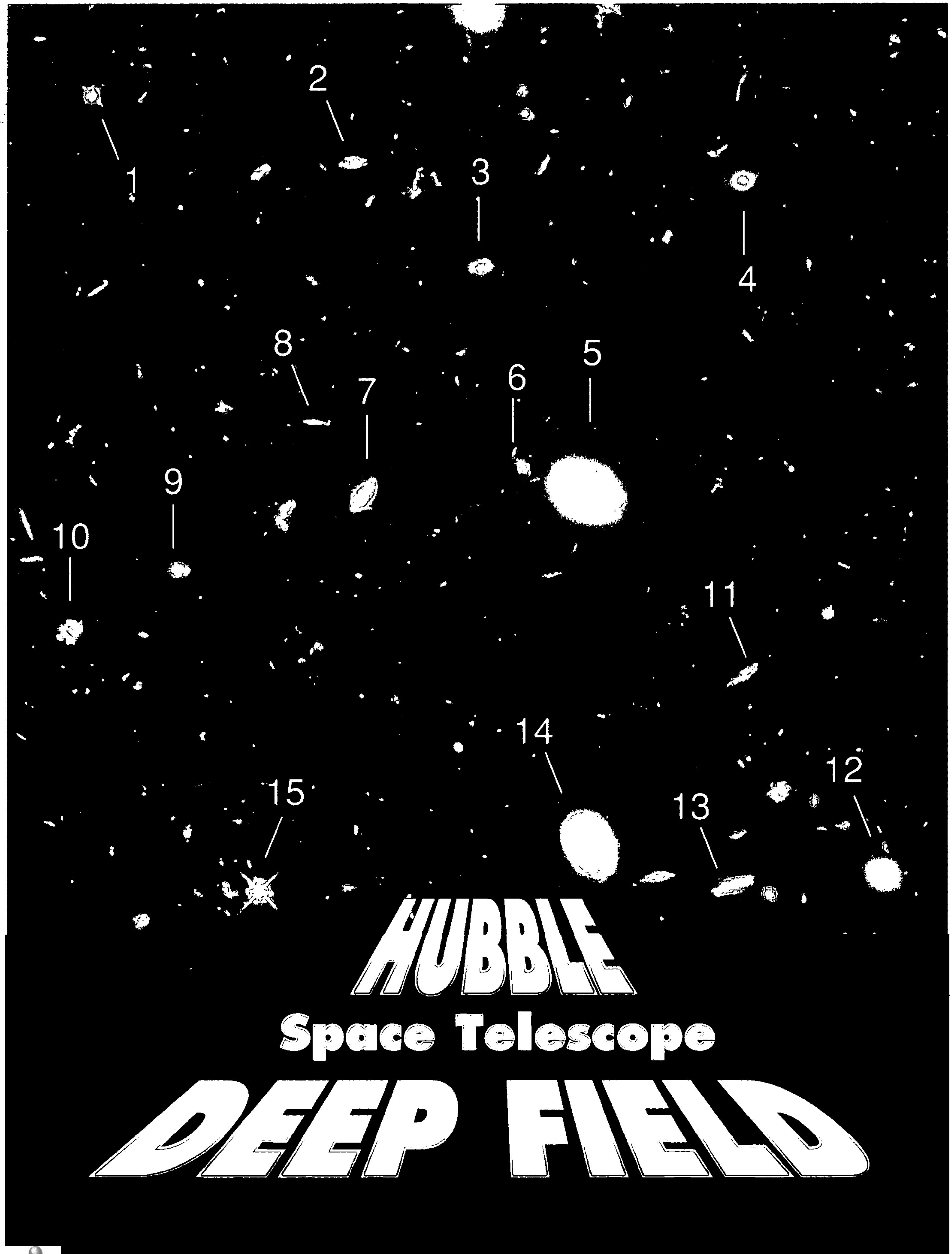
Why Is the WFPC2 Field Chevron-Shaped?
The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Electronic Access
You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
HUBBLE
Space Telescope
DEEP FIELD

Galaxies
- Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape
- Astronomers use shape to classify galaxies.
- There are three commonly recognized shapes: spiral, elliptical, and irregular.

Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.

Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.

Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
- The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

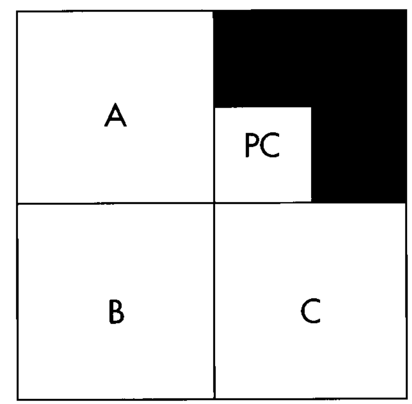
Color
- Galaxies come in a variety of colors.
- As a galaxy ages, its color changes.
- Galaxies with young stars would appear blue while galaxies with old stars would appear red.
- Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
- The presence of dust in a galaxy can make it appear more red than it actually is.
- By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance
- Determining the distance from Earth for objects in space is a difficult task for astronomers.
- The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
- Astronomers study the light from galaxies to determine their distance, which is measured in light years.
- A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

Hubble Deep Field–Camera A
The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

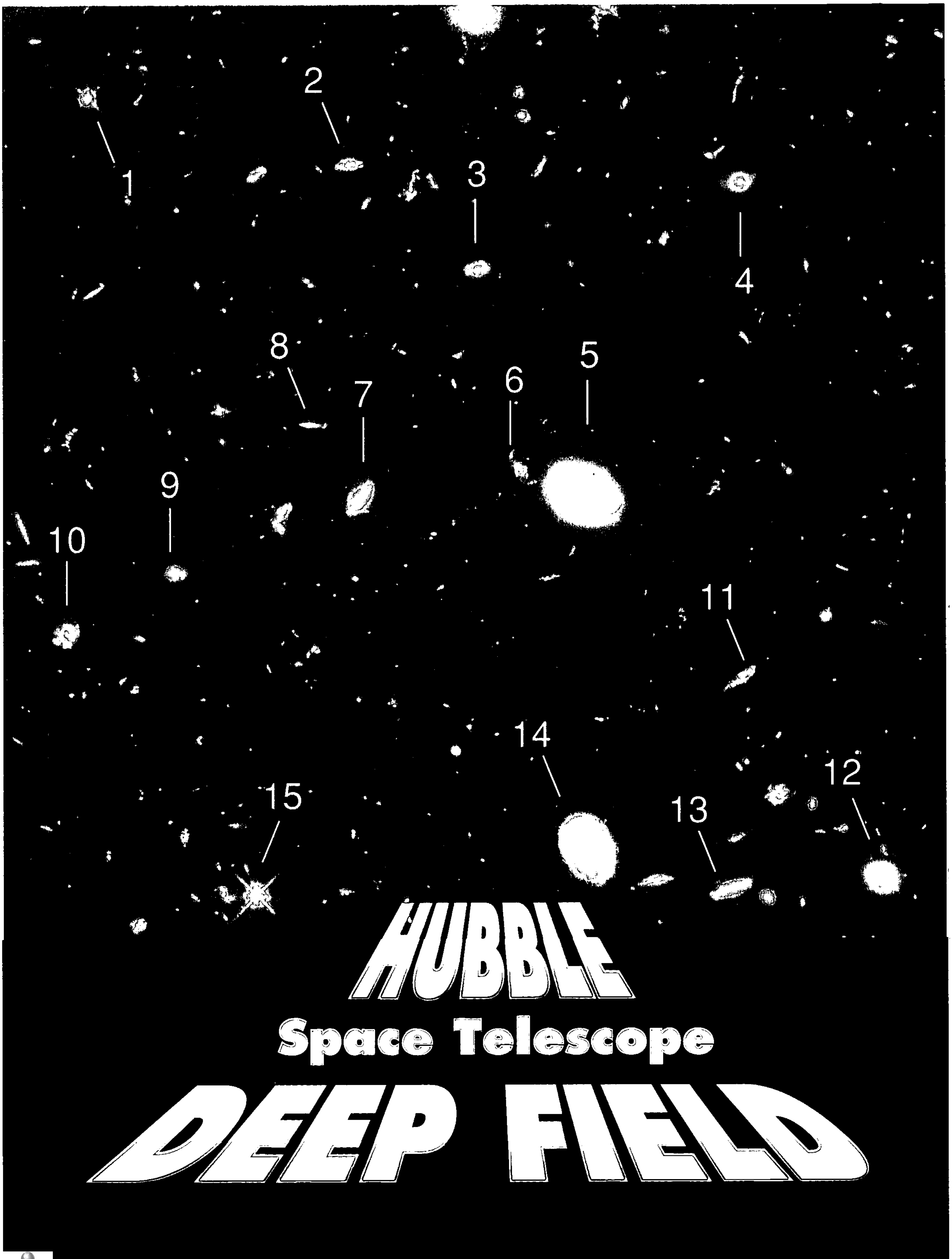
Why Is the WFPC2 Field Chevron-Shaped?
The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Electronic Access
You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
HUBBLE
Space Telescope
DEEP FIELD

Galaxies

• Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape

• Astronomers use shape to classify galaxies.
• There are three commonly recognized shapes: spiral, elliptical, and irregular.

Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.

Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.

Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.

• The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

Color

• Galaxies come in a variety of colors.
• As a galaxy ages, its color changes.
• Galaxies with young stars would appear blue while galaxies with old stars would appear red.
• Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
• The presence of dust in a galaxy can make it appear more red than it actually is.
• By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance

• Determining the distance from Earth for objects in space is a difficult task for astronomers.
• The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
• Astronomers study the light from galaxies to determine their distance, which is measured in light years.
• A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

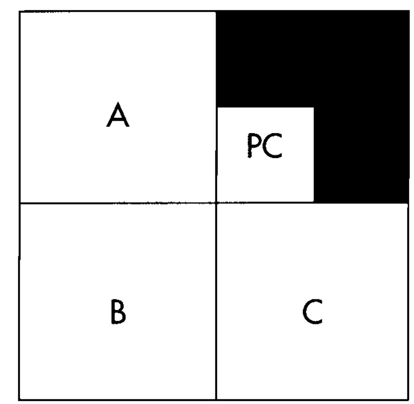
Hubble Deep Field–Camera A

The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

Why Is the WFPC2 Field Chevron-Shaped?

The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.

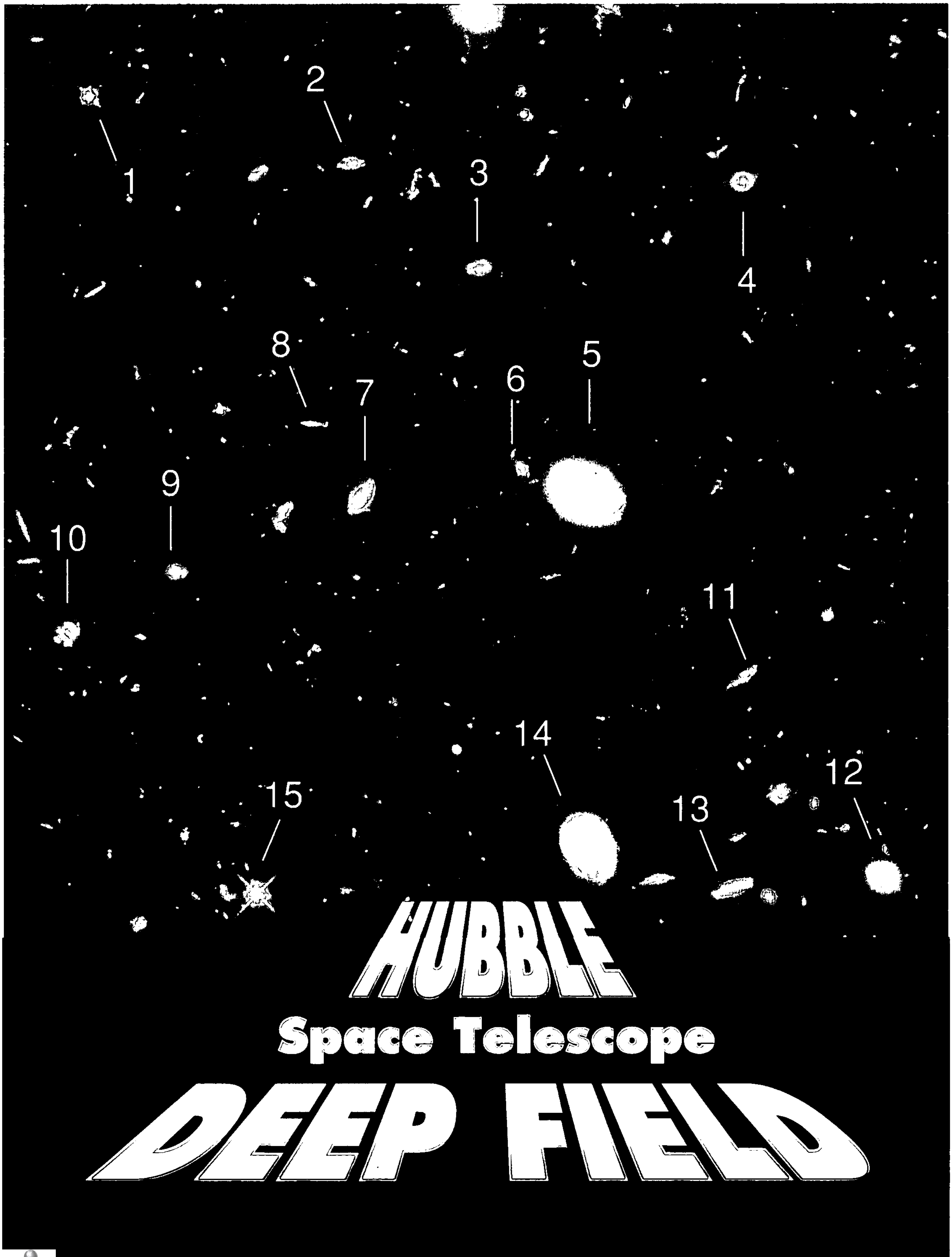


Electronic Access

You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
HUBBLE
Space Telescope
DEEP FIELD

SPACE TELESCOPE SCIENCE INSTITUTE · NASA · esa european space agency

Galaxies
• Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape
• Astronomers use shape to classify galaxies.
• There are three commonly recognized shapes: spiral, elliptical, and irregular.
Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.
Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.
Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
• The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

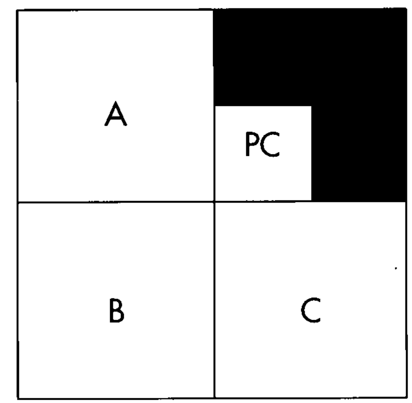
Color
• Galaxies come in a variety of colors.
• As a galaxy ages, its color changes.
• Galaxies with young stars would appear blue while galaxies with old stars would appear red.
• Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
• The presence of dust in a galaxy can make it appear more red than it actually is.
• By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance
• Determining the distance from Earth for objects in space is a difficult task for astronomers.
• The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
• Astronomers study the light from galaxies to determine their distance, which is measured in light years.
• A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

Hubble Deep Field–Camera A
The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

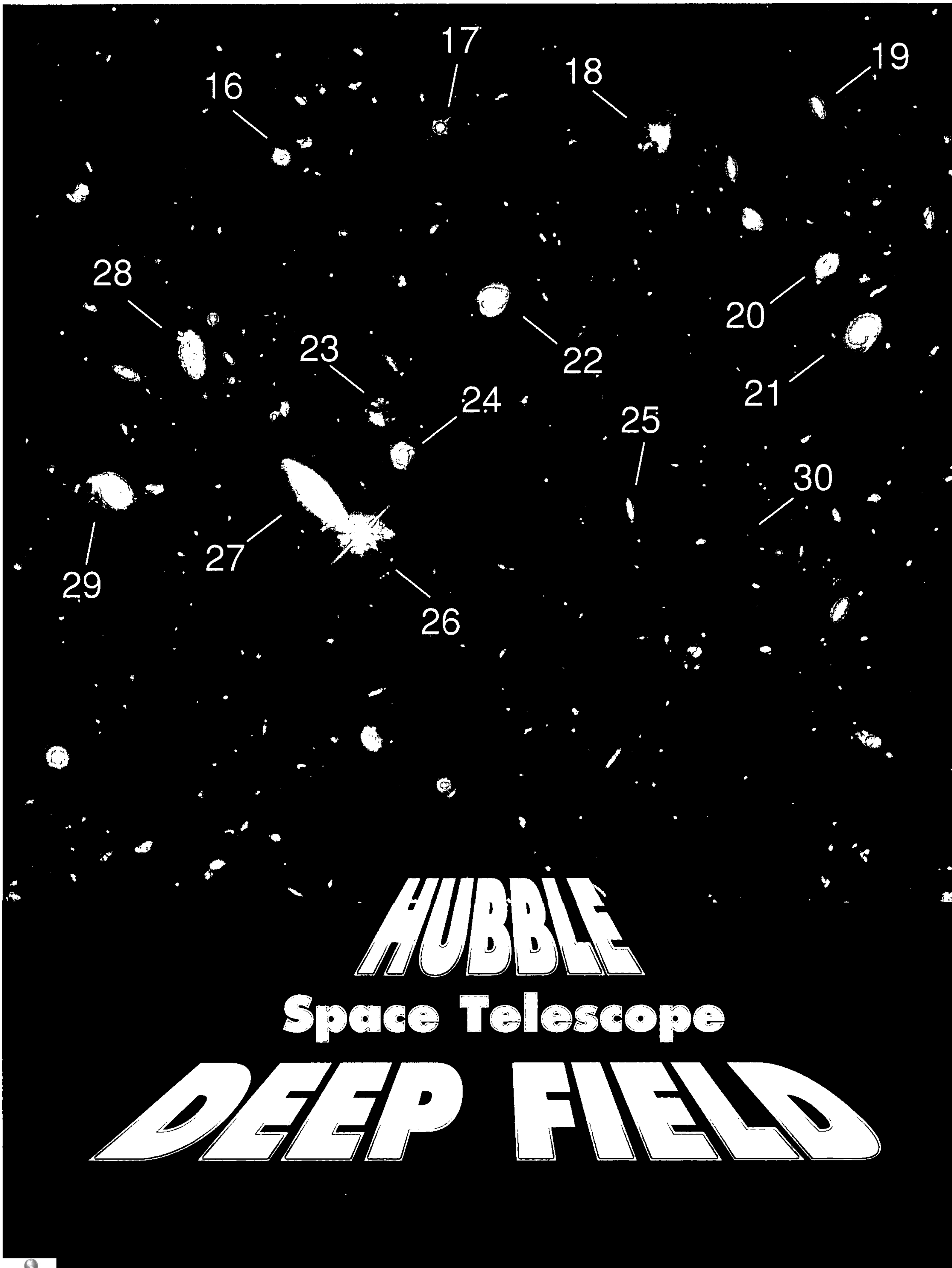
Why Is the WFPC2 Field Chevron-Shaped?
The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Electronic Access
You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


16
17
18
19
28
20
22
23
21
24
25
30
27
29
26
HUBBLE
Space Telescope
DEEP FIELD

Galaxies
• Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape
• Astronomers use shape to classify galaxies.
• There are three commonly recognized shapes: spiral, elliptical, and irregular.
Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.
Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.
Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
• The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

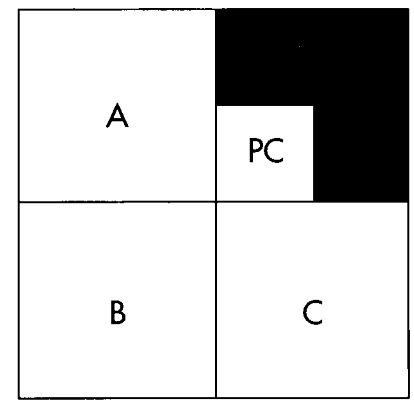
Color
• Galaxies come in a variety of colors.
• As a galaxy ages, its color changes.
• Galaxies with young stars would appear blue while galaxies with old stars would appear red.
• Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
• The presence of dust in a galaxy can make it appear more red than it actually is.
• By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance
• Determining the distance from Earth for objects in space is a difficult task for astronomers.
• The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
• Astronomers study the light from galaxies to determine their distance, which is measured in light years.
• A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

Hubble Deep Field–Camera B
The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

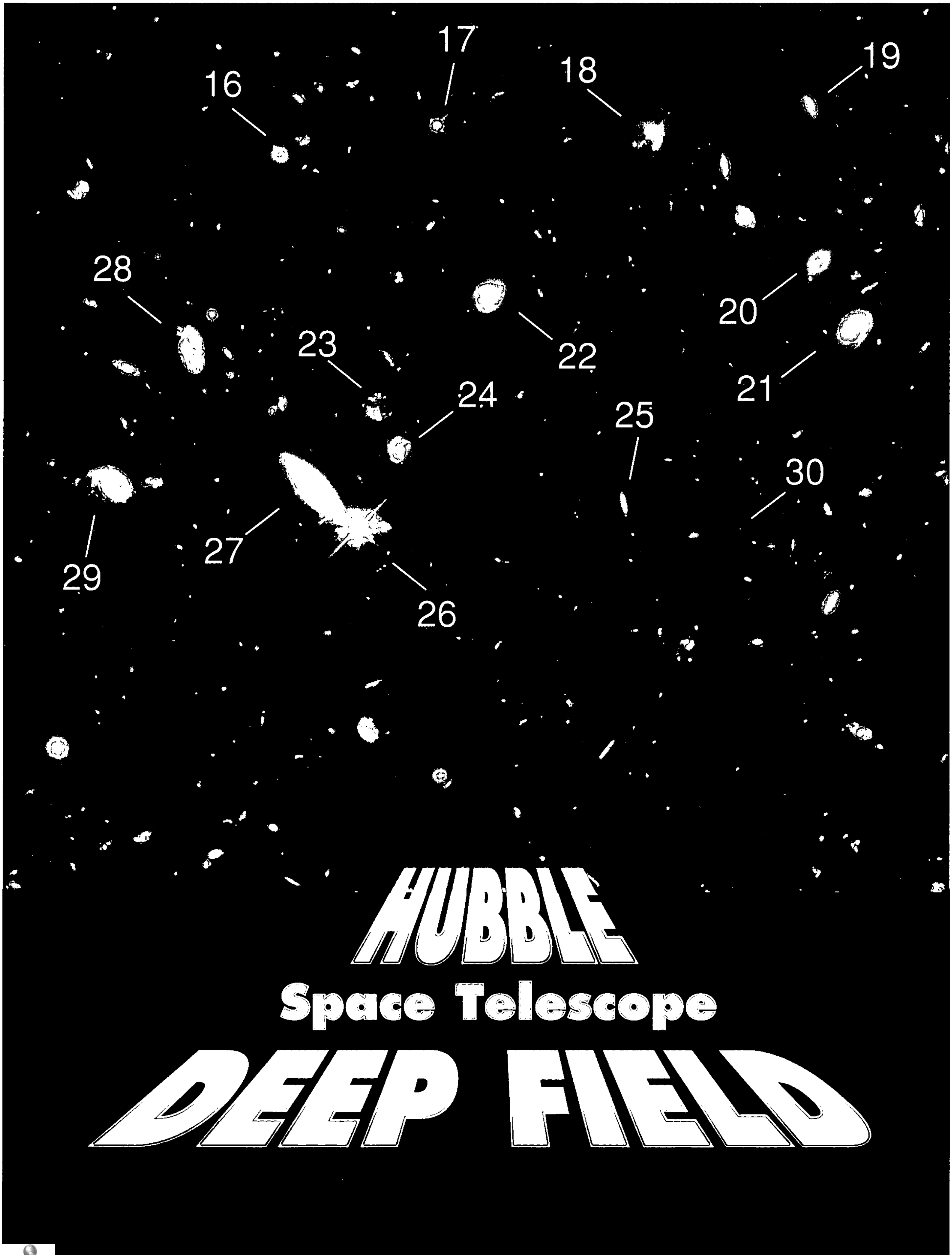
Why Is the WFPC2 Field Chevron-Shaped?
The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Electronic Access
You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
HUBBLE
Space Telescope
DEEP FIELD

SPACE TELESCOPE SCIENCE INSTITUTE

Galaxies
• Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape
• Astronomers use shape to classify galaxies.
• There are three commonly recognized shapes: spiral, elliptical, and irregular.
Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.
Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.
Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
• The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

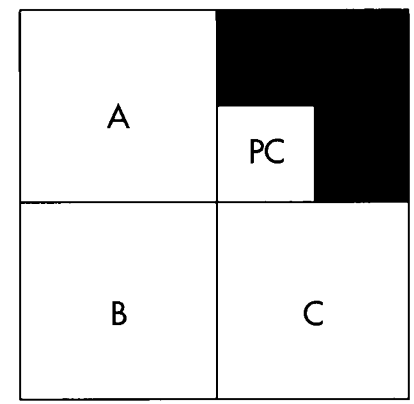
Color
• Galaxies come in a variety of colors.
• As a galaxy ages, its color changes.
• Galaxies with young stars would appear blue while galaxies with old stars would appear red.
• Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
• The presence of dust in a galaxy can make it appear more red than it actually is.
• By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance
• Determining the distance from Earth for objects in space is a difficult task for astronomers.
• The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
• Astronomers study the light from galaxies to determine their distance, which is measured in light years.
• A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

Hubble Deep Field–Camera B
The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

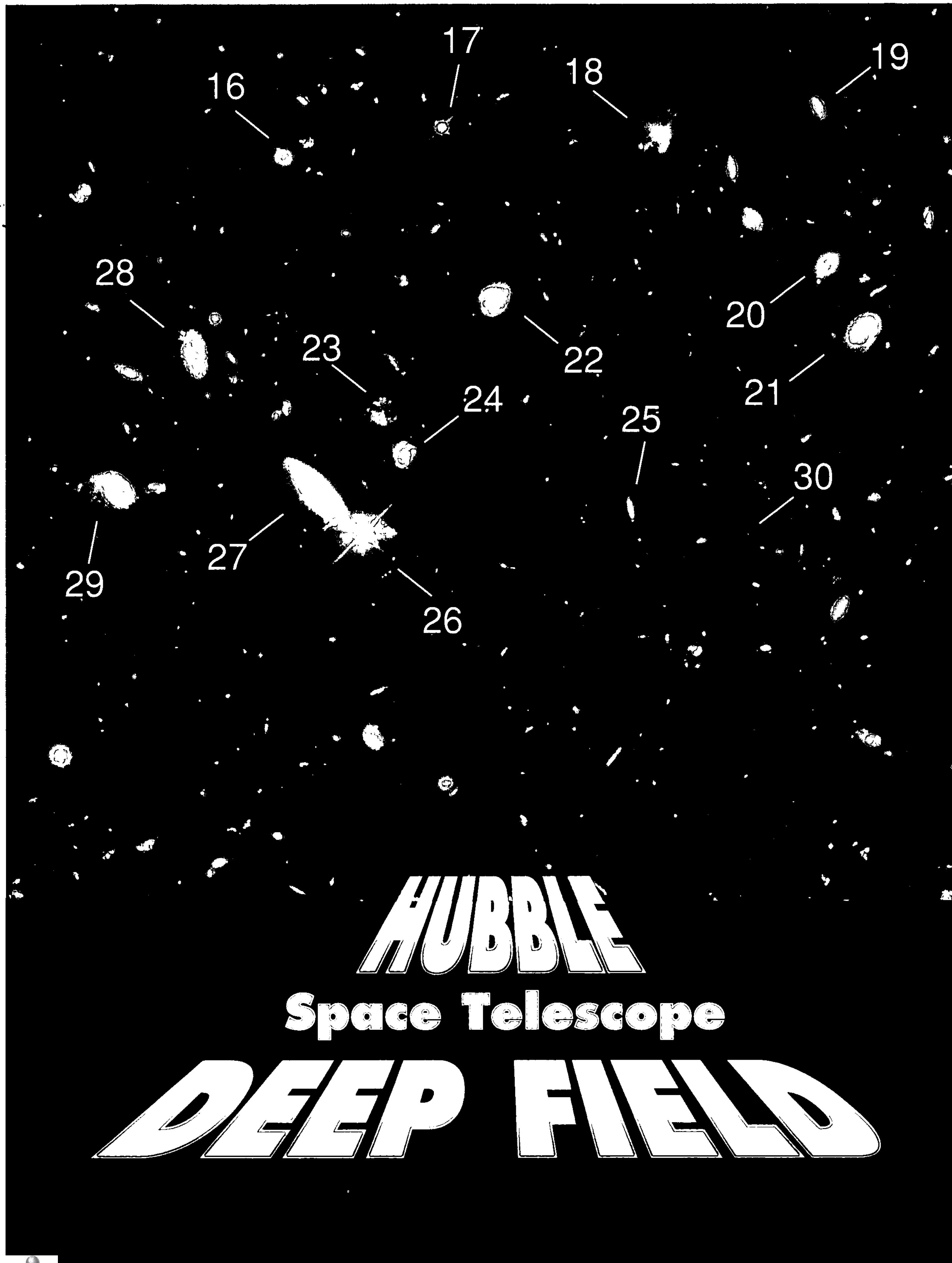
Why Is the WFPC2 Field Chevron-Shaped?
The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Electronic Access
You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
HUBBLE
Space Telescope
DEEP FIELD

Galaxies

• Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape

• Astronomers use shape to classify galaxies.
• There are three commonly recognized shapes: spiral, elliptical, and irregular.

Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.

Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.

Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.

• The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

Color

• Galaxies come in a variety of colors.
• As a galaxy ages, its color changes.
• Galaxies with young stars would appear blue while galaxies with old stars would appear red.
• Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
• The presence of dust in a galaxy can make it appear more red than it actually is.
• By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance

• Determining the distance from Earth for objects in space is a difficult task for astronomers.
• The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
• Astronomers study the light from galaxies to determine their distance, which is measured in light years.
• A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

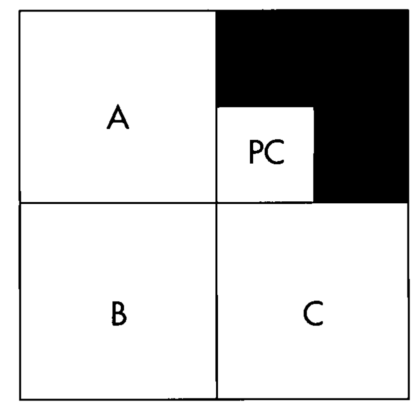
Hubble Deep Field–Camera B

The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

Why Is the WFPC2 Field Chevron-Shaped?

The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.

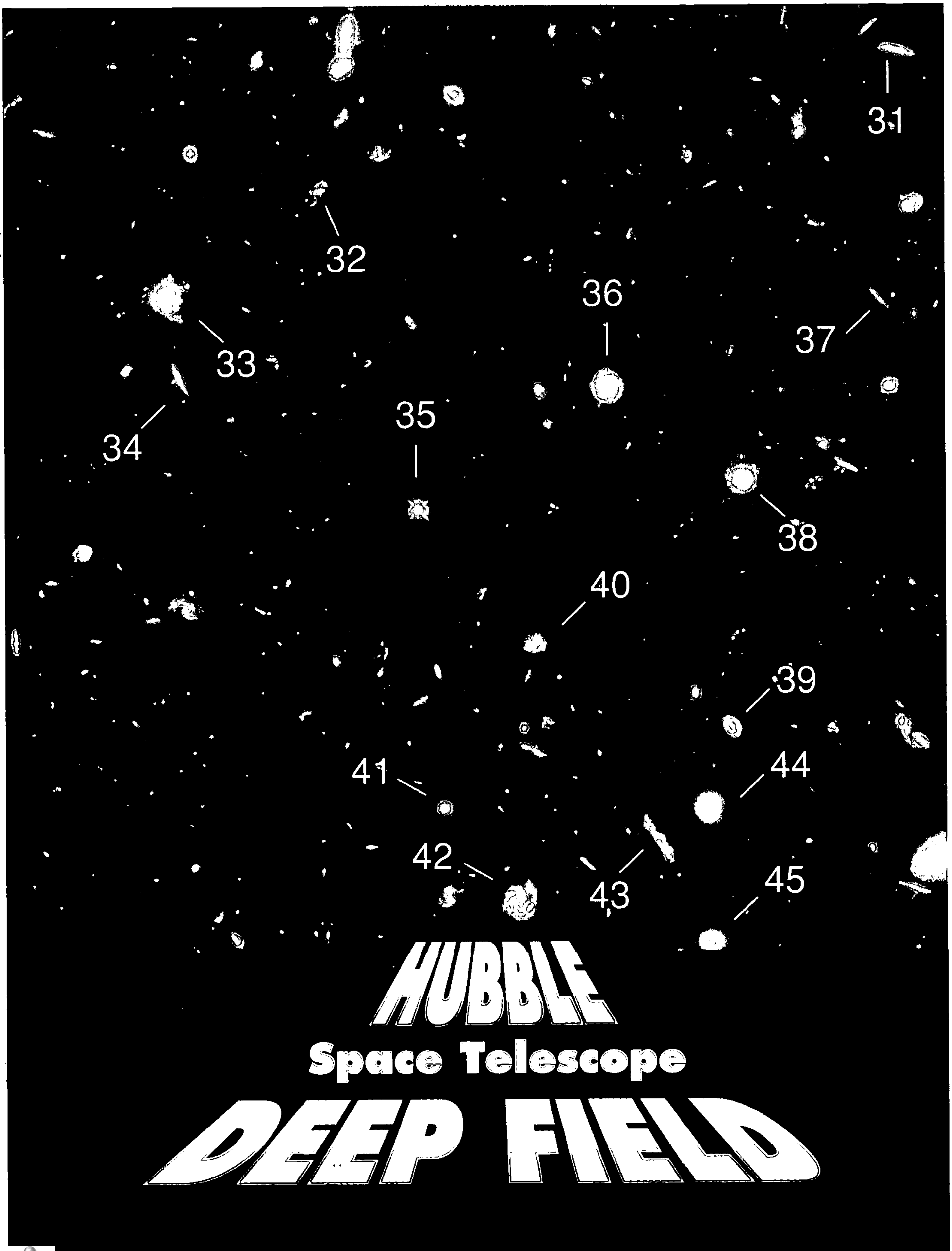


Electronic Access

You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
HUBBLE
Space Telescope
DEEP FIELD

Galaxies
• Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape
• Astronomers use shape to classify galaxies.
• There are three commonly recognized shapes: spiral, elliptical, and irregular.

Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.

Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.

Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
• The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

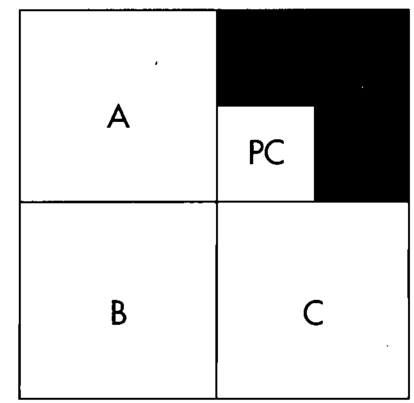
Color
• Galaxies come in a variety of colors.
• As a galaxy ages, its color changes.
• Galaxies with young stars would appear blue while galaxies with old stars would appear red.
• Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
• The presence of dust in a galaxy can make it appear more red than it actually is.
• By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance
• Determining the distance from Earth for objects in space is a difficult task for astronomers.
• The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
• Astronomers study the light from galaxies to determine their distance, which is measured in light years.
• A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

Hubble Deep Field–Camera C
The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

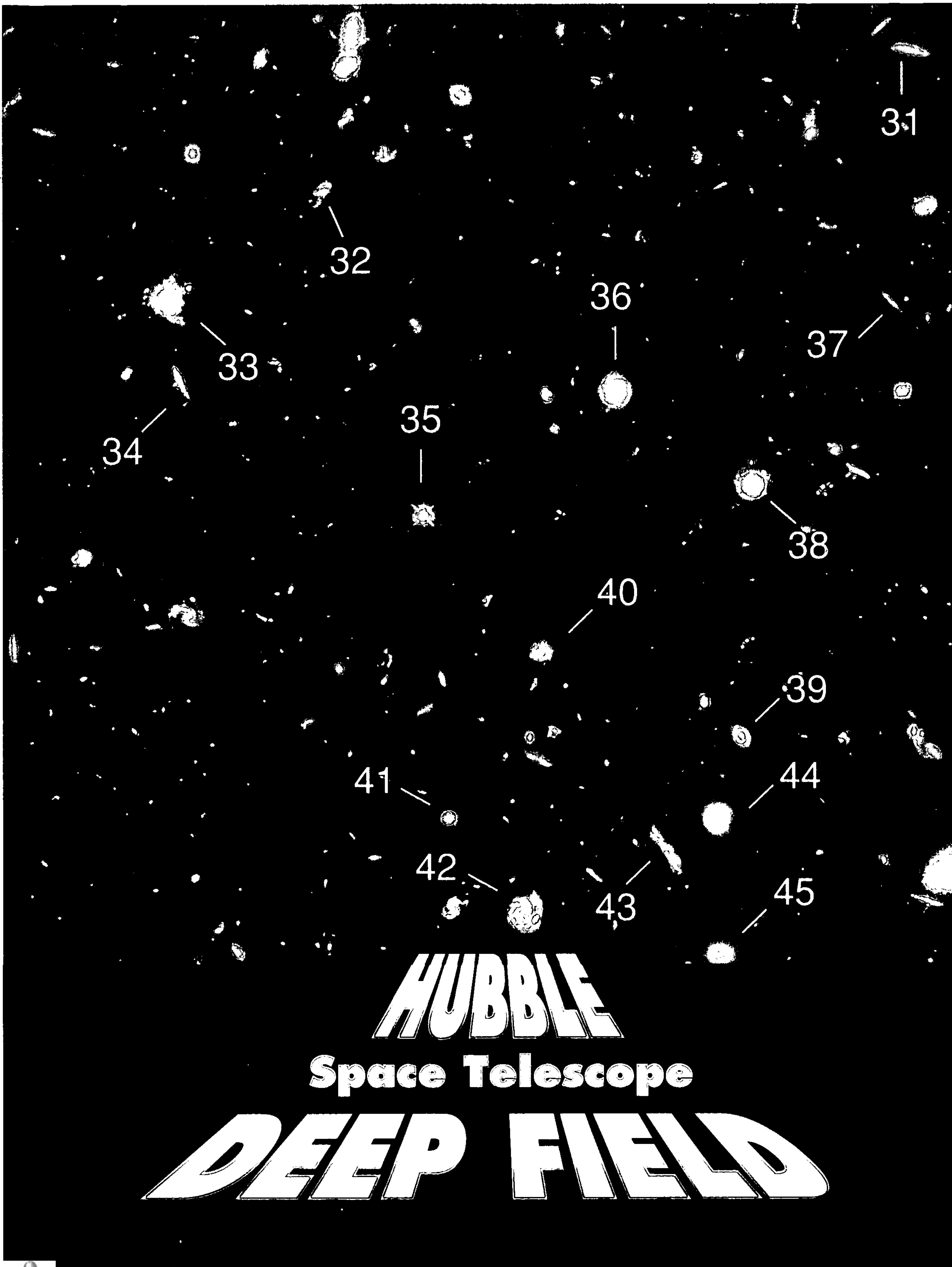
Why Is the WFPC2 Field Chevron-Shaped?
The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Electronic Access
You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
HUBBLE
Space Telescope
DEEP FIELD

SPACE TELESCOPE SCIENCE INSTITUTE

Galaxies
• Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape
• Astronomers use shape to classify galaxies.
• There are three commonly recognized shapes: spiral, elliptical, and irregular.

Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.

Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.

Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
• The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

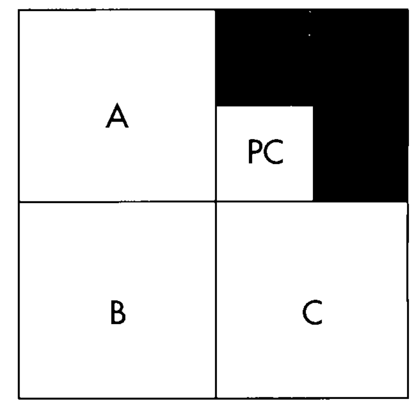
Color
• Galaxies come in a variety of colors.
• As a galaxy ages, its color changes.
• Galaxies with young stars would appear blue while galaxies with old stars would appear red.
• Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
• The presence of dust in a galaxy can make it appear more red than it actually is.
• By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance
• Determining the distance from Earth for objects in space is a difficult task for astronomers.
• The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
• Astronomers study the light from galaxies to determine their distance, which is measured in light years.
• A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

Hubble Deep Field–Camera C
The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

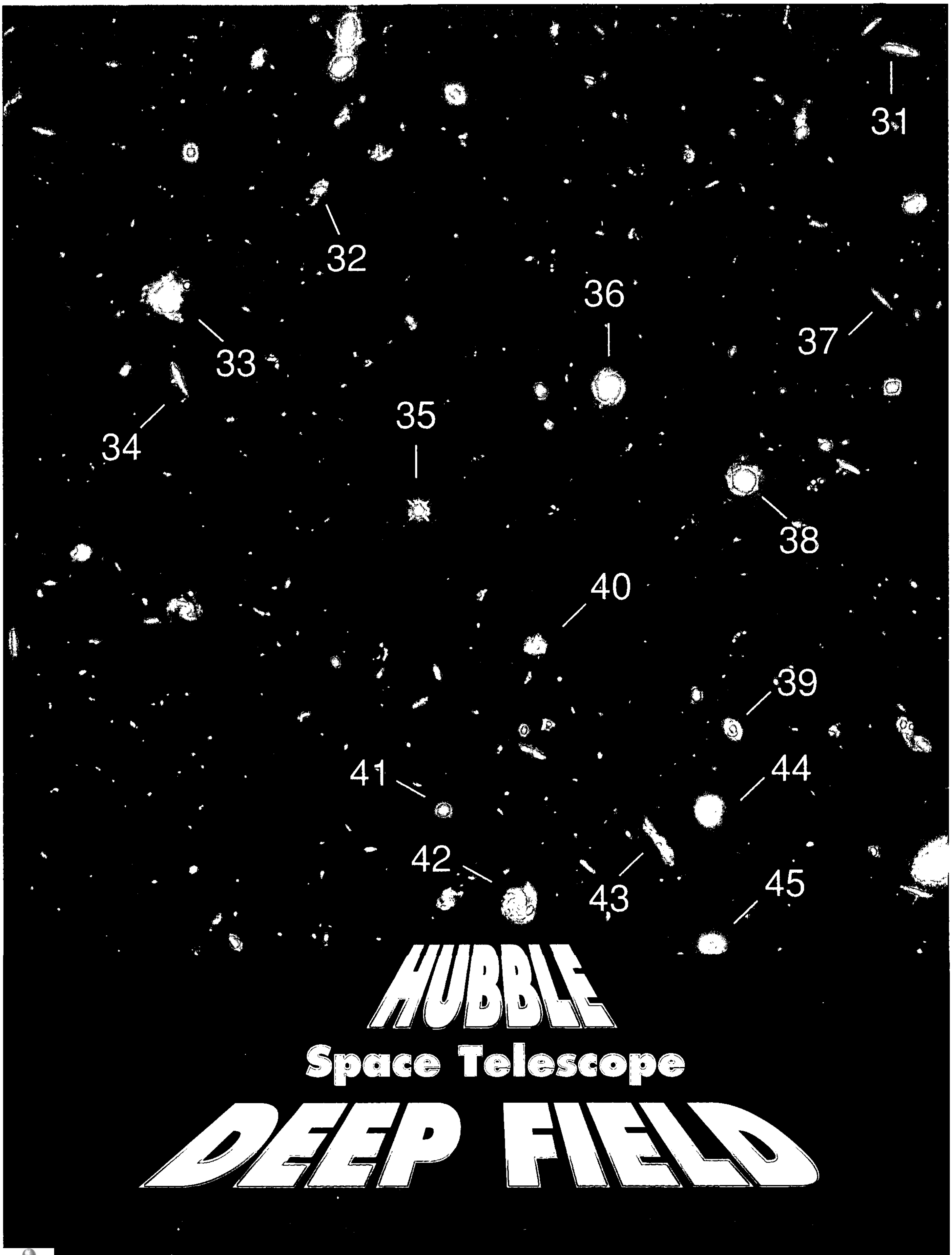
Why Is the WFPC2 Field Chevron-Shaped?
The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Electronic Access
You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").


31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
HUBBLE
Space Telescope
DEEP FIELD

Galaxies
- Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.

Shape
- Astronomers use shape to classify galaxies.
- There are three commonly recognized shapes: spiral, elliptical, and irregular.

Spiral galaxies have two or more "arms" winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.

Elliptical galaxies appear smooth and featureless, with round or oval shapes, and look basically the same when viewed from any angle.

Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
- The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

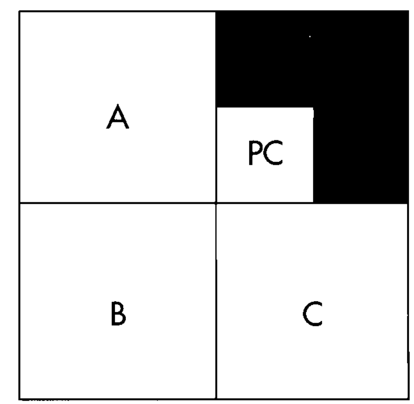
Color
- Galaxies come in a variety of colors.
- As a galaxy ages, its color changes.
- Galaxies with young stars would appear blue while galaxies with old stars would appear red.
- Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
- The presence of dust in a galaxy can make it appear more red than it actually is.
- By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance
- Determining the distance from Earth for objects in space is a difficult task for astronomers.
- The size of a galaxy is not useful because objects that are close can appear small next to other objects that are extremely large and far away.
- Astronomers study the light from galaxies to determine their distance, which is measured in light years.
- A light year is equal to the distance light can travel in a year, approximately 6 trillion miles.

Hubble Deep Field–Camera C
The Hubble Space Telescope reached back 10 billion years to capture the image shown on the front. The Hubble Deep Field shows the dimmest, most distant objects in the universe. The image, the longest Hubble exposure yet taken, was made by pointing the telescope at one point in the sky continously for 10 days.

The Hubble Deep Field shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length. The field lies in a dark patch of sky just above the Big Dipper. This field is so narrow that just a few foreground stars in our Milky Way Galaxy are visible.

Why Is the WFPC2 Field Chevron-Shaped?
The Wide Field Planetary Camera 2 (WFPC2) is actually four cameras in one; each camera looks at adjacent pieces of the sky. The resulting four separate pictures are combined together, like tiles, to create a mosaic. Three of the cameras (labeled A, B, C) are "wide field" but only in a relative sense. They look at a piece of sky only one-tenth the diameter of the full moon. A fourth camera, called the "planetary camera" (labeled PC) has an even narrower view, and looks at an area of sky only one-fourth the area of the wide field cameras but at twice the resolution. The image from the smaller camera, when combined with the three wide field images, create the unique "stair step" appearance of full field WFPC2 pictures.



Electronic Access
You can get the complete lesson plan and additional information about the Hubble Deep Field, along with other images and information about the Hubble Space Telescope, by using the Internet.

Using the World Wide Web (Mosiac, NetScape, Lynx, and other browsers), use URL http://www.stsci.edu/pubinfo/amazing-space.html, and follow the links from there.

For other sources of information, follow the links to the Hubble Deep Field Lesson Plan Grab Bag (resources are linked through "Outside STScI").

NOTICE

Reproduction Basis

- [ ] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

- [x] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").